

THE ATLANTIC-GULF OF MEXICO HURRICANE OF OCTOBER 30 TO NOVEMBER 8, 1935

By WILLIS E. HURD

[Weather Bureau, Washington, December 1935]

Following closely upon the Caribbean hurricane of October 19-26, 1935, described in the preceding issue of the REVIEW as moving over a peculiar and unprecedented track, the hurricane of early November 1935 will likewise pass into history as a tropical storm of erratic movement, and the first of record to develop hurricane intensity at so late a date over the southern part of the Florida Peninsula.

This storm seemingly was of extratropical origin, since it first appeared as a small and weak depression central about 32° N., some distance east of Bermuda, early on October 30. It progressed west-by-north, passed close north of Bermuda, and, continuing in a general west-by-north to west-northwesterly course with increasing intensity, became a distinct threat to the entire Carolina coast by the morning of November 1. During the night of November 1, however, it unexpectedly turned southwestward, and by the 2d proceeded almost due south, crossed the northern extremity of the Bahamas on the 3d, and then passed southwesterly across the lower Florida Peninsula into the Gulf of Mexico on the 4th. In the east Gulf it formed an incomplete loop by first moving westward, then northward toward the Alabama coast, and finally eastward nearly to the central west coast of Florida. It did not reach this coast, but entirely disintegrated before 8 p. m. on November 8.

This storm throughout its history was of comparatively small diameter, and its hurricane winds covered only a narrow band.

During October 30, anticyclonic conditions prevailed to the west, north, and northeast of Bermuda, with little signs of breaking, yet at the 8 a. m. observation Bermuda's pressure had fallen decidedly since the previous night to 30.04, with wind from the north, force 7. At 8 p. m. of the 30th, pressure at Bermuda had fallen further to 29.86, with wind from the northwest, force 4. A short distance to the northwest of the island, the British steamship *Monarch of Bermuda* had a northwest wind of force 7, barometer 29.80. A definite Low was thus indicated to be advancing close to the northward of the island.

On the 31st the center of the disturbance moved west-by-north and showed definite signs of developing hurricane intensity. Near midnight on October 31, the American steamship *W. H. Libby* at latitude 34°43' N. and longitude 69°16' W. entered the zone of gale winds, reporting southeast, force 8. The gale winds continued until the afternoon of November 1, changing only slightly to an east-southeast direction and attaining force 9. The lowest barometer reading on this vessel was at 2 a. m. on November 1, when a corrected value of 29.58 inches was indicated. A few hours later the American steamship *Altair*, on the west side of the disturbance at 33°54' N., 74°56' W., reported northwest gales with a barometer reading of about the same value as that on the *W. H. Libby*.

The weather chart prepared at 8 a. m., eastern standard time, November 1, is reproduced in chart IX, at the end of this REVIEW. This places the center of the disturbance at about 34° N., 70½° W. The lowest barometer at this time probably was 29.20 inches or less. At 10 a. m. of this date the American steamship *W. C. Teagle* encountered a southeast gale of force 10, in 35°00' N., 68°50' W., with, however, only a moderate depression of the barometer. At 2 p. m. of the 1st the American steamship

Borinquen, in 35°20' N., 72°05' W., reported a barometer reading of 29.26 inches, wind east, force 11, as the ship came closest to the north side of the intensifying storm center. At 4 p. m., as the storm moved westward, she was in the northeast quadrant, with wind southeast, force 10, and pressure risen to 29.46. Eight hours later, at midnight, the American steamship *W. S. Farish* experienced a northeast gale of force 11, barometer 29.42, in 34°30' N., 75°00' W. These observations indicate how closely the gale winds on the western side of the hurricane approached to the North Carolina coast during November 1. The maximum wind velocity observed at Hatteras on this day was 40 miles per hour from the north.

Between the mornings of November 1 and 2, and particularly during the night of the 1st, the storm center took a peculiar turn toward a more southerly course. By 8 p. m. eastern standard time, the hurricane had already shown a tendency to move southward by changing its course from west-by-north, to west-southwest. On the morning of November 2 it was headed toward the south-southwest and moving somewhat more rapidly than before, but still at the moderately slow rate of about 13 miles per hour.

This abnormal change in direction was accompanied by a further increase in intensity. The American steamship *Iowan* passed through the central calm area at about 2 a. m. on November 2, in 33°30' N., 74°42' W. The barometer at that time stood at 28.94 inches. Just before the passage through the calm, the wind had attained force 12 from the north-northeast. Force 12 from southwest shortly thereafter indicated that the ship had passed from the calm center into the other side of the hurricane. The highest wind intensity, force 12, however, was only momentary according to the reports of Capt. L. Laverge, for the vessel soon ran into a wind of force 10 from north-northeast. By 6 a. m., the ship, which was heading toward Norfolk, passed out of the zone of gales as the wind, which was then east-northeast, diminished to less than force 8.

The position of the center on the morning of November 2 is shown by chart X. (The full track of the storm with its various positions, is shown in connection with chart XII.)

The center on November 2 was nearly 200 miles south of Cape Hatteras. During the next 24 hours the storm moved south-southwest to south at about 13 miles per hour to a position at 7 a. m., November 3, about 100 to 110 miles north-northeast of Great Abaco Island, Bahamas. At 9:30 a. m. the British steamship *Queen of Bermuda*, about 75 miles north-northeast of Hopetown, Great Abaco Island, in 27°41' N., 76°32' W., was in the hurricane center, with a barometer reading of 28.46 inches, the lowest reported for this storm. The vessel hove to for an hour during the passage of the central area, in which only a moderate easterly breeze was experienced, surrounded by a narrow band of hurricane inds.

The following description of the subsequent action of the storm is taken from the report of Gordon E. Dunn, forecaster of the Weather Bureau at Jacksonville, Fla.

At 7 p. m. November 3 the center was a short distance north of Hopetown, Great Abaco Island. The rate of movement between 10 a. m. and 7 p. m. this date was between 6 and 7 miles per hour,

just about half that of the previous day. Thus it would seem that the change in direction of movement (see below) took place in the afternoon and early night of the 3d when the rate of translation was the slowest. Hurricane winds lasted on Great Abaco from 1 to 3 hours. According to press reports 14 lives, including that of the Commissioner, were lost on this island, notwithstanding very definite and adequate warnings as well as the fact that the storm was barely of hurricane intensity and was of short duration.

It may be added that Commissioner John Eldridge Russell lost his life, through the sudden swing of a ship's boom which threw him into the sea, while engaged in distributing relief supplies from a sailboat to islanders who suffered in the hurricane of the previous September 28. Five vessels of the island sponge fleet were reported lost.

"After passing over Great Abaco Island between Hopetown and Green Turtle Cay", continues Mr. Dunn's report, "the storm pursued a straight course west-southwest to Miami."

A report from the American steamship *Arizpa*, Mobile toward London, caught in the hurricane off the south-east coast of Florida, states that the barometer stood at 28.72 inches (corrected) from 11 a.m. until noon of the 4th, at and close to 25° 55' N., 79° 55' W., while hurricane velocities from north and northeast were experienced between 10 a.m. and 1 p.m.

As the storm struck the lower southeast coast of Florida on the 4th, winds of gale force extended northward to West Palm Beach, while winds of hurricane force of short duration were confined to the Fort Lauderdale-Miami neighborhood.

To quote from the report by the Weather Bureau at Miami:

Winds of force 12 from the east, with lowest barometer of 28.86 inches, were reported by Coast Guard base 6 at Fort Lauderdale, Fla., while winds of hurricane force, with heavy seas, and lowest barometer of 29.10 inches at 1:45 p. m., were reported from Fowey Rock Lighthouse. The time of occurrence of the lowest barometer at Fort Lauderdale was 1 p. m. In Miami, which was directly in the path of the center of the disturbance, the lowest barometer was 28.73 inches at 1:45 p. m., and the maximum wind velocity 75 miles per hour from the southeast at 2:07 p. m. The extreme velocity (fastest mile) was 94 miles per hour at 2:17 p. m., at which time exceptionally strong gusts and considerable pumping of the barometer were noted. The duration of the lull at the downtown office and the airport station was practically the same, being 1 hour and 5 minutes, the exact center of the storm passing between the two points as the wind backed from west-northwest to southeast at the airport station, and veered from west-northwest to southeast at the downtown office. A lull of 1 hour was reported from Sunny Isle, which is a short distance north of Miami Beach, while a lull of 15 minutes was noted at Hallandale, Fla.

The report goes on to say that, from the information at hand, the width of the eye of the storm is estimated at 15 miles. The sky did not clear, at least materially, although the rain stopped and some persons reported seeing the sun for a short time.

Damage to buildings in the Miami area, including that done by water to interiors after roofs were demolished or torn, was estimated at \$4,500,000; public utility losses, \$750,000; small craft in harbor, \$120,000. The loss to vessels was confined mostly to two yachts which broke from their moorings and drifted into the causeway, as other small craft secured safe anchorage in the Miami River. Damage estimated at \$150,000 was inflicted on trees and tropical shrubbery in the city and surrounding territory. The total property loss in Miami and vicinity is estimated at \$5,500,000. Although 115 persons are known to have been injured in the area extending from Fort Lauderdale southward to Miami, and southwestward across the lower end of the peninsula, fortunately

only 5 deaths have been reported. The total loss of life in Florida and Great Abaco Island is thus placed at 19.

The position of the storm, together with pressure and wind distribution over surrounding areas, is shown for the morning of November 4 in chart XI, only a few hours before the center reached Miami.

From the Florida east coast, the hurricane center crossed the Everglades and entered the Gulf of Mexico near to or just north of Cape Sable on the evening of the 4th. On the morning of the 5th, the storm was central near 25° N., 83° W. During this day the British motorship *Horn Shell* reported winds of hurricane force at two different observations in the southeastern Gulf. This ship was the last to report similarly intense winds, as the storm moved forward subsequently to the 5th with rapidly decreasing energy, recurring gradually to the right.

Shortly after midnight on the early morning of the 6th the American steamship *Mariana* encountered a northerly gale of force 9, which continued for several hours during the ship's progress northward toward Mobile. The lowest barometer reported by the *Mariana* was 29.77, in 25°49' N., 85°42' W., at 5 a. m. At about 8 a. m. of the 6th the American steamship *Hanover*, in 27°00' N., 86°12' W., encountered the last reported gale, a wind of force 8 from the south, in connection with the storm. This ship, in a voyage from Baltimore toward New Orleans, had previously encountered whole gales (force 10) along the storm track—the first experienced on November 2, in 33°53' N., 75°38' W., and the second on the 4th, in 25°22' N., 80°06' W.

On the evening of the 6th the center of the disturbance, moving northward, had attained its westernmost location at about 87° W., in about 27° N., and was showing a small tendency to recurve into north-northeast. Thereafter, on the 7th and 8th, the narrowing depression moved northeast, and then east until its complete dissipation. During the last 3 days of its existence in the Gulf, while it affected the direction of the coastal winds to the northward and eastward, it caused no fall from normal barometer at coast stations from New Orleans to Tampa.

In discussing the winds, clouds, precipitation, and tidal effects observed in connection with the storm, G. E. Dunn, of the Jacksonville Weather Bureau Office, says:

Many peculiarities attended this storm aside from its most unusual path. About 0.24 inch of rain fell at Miami before the arrival of the lull and about 3.80 inches after passage of the center. I have no recollection of any such rainfall distribution at any place over which the center of a tropical storm passed. Indeed, the heaviest rainfall usually occurs in the front quadrants and least in the rear. Reports from cooperative stations indicated that decidedly heavier precipitation occurred in the left-hand quadrant than in the right, also unusual. Winds prevailed in greater conformity to precedent and near hurricane winds prevailed for about twice the distance to the right of the center than to the left. The wind circulation in the Bahamas and on the southeast Florida coast did not conform exactly to the type case for a circular low. After the center had passed to the south, northwest winds continued for several hours after one would have expected north or northeast winds. The hurricane was apparently not wholly circular and had several extratropical characteristics. No cirrus clouds outran the storm to any extent. Miami reported that the first clouds appeared as a solid alto-stratus cloud sheet moving rapidly in from the northeast about 9 hours before the arrival of the lull. Although the center of the storm passed about 300 miles east of Jacksonville and the visibility was very good, no clouds at all were visible on the eastern horizon.

No report of any extremely high tide in connection with this storm has been received. At Miami a tide of 5 feet, 2.2 above normal, was reported at 2 p. m., a few minutes after passage of the calm center. At Pigeon Key in Biscayne Bay, an estimated reading of almost 6 feet was made. A high tide was reported at Fort Lauderdale following passage of the axis of the storm center and wind shift from northwest to easterly, but details are lacking.

R. A. Dyke, of the Weather Bureau forecast center at New Orleans, in reporting on the tidal conditions in that district during the final stages of the storm, said that "tides were highest on the 6th and 7th, but did not exceed 1.5 feet above normal from Pensacola to Apalachicola, and were lower than that elsewhere."

Warnings issued by the Weather Bureau in connection with the hurricane were ample and timely. On the morning of October 31, when the storm was a short distance to west-northwestward of Bermuda, the Bureau issued an advisory warning, and followed it by a second advisory message after receipt of the evening observations of the same date. On November 1 storm warnings were ordered up on the North Carolina coast, and on the 2d, extended to Charleston, S. C., with cautionary warnings covering the whole east coast to the southward. Full information of the movements of the storm on the 3d, accompanied by cautionary advices, were broadcast to all vessels and interests from the Bahamas to the Florida coast. The first order to hoist hurricane warnings was issued by the Jacksonville office on November 4, 1935, as follows:

Hoist 7:30 a. m. hurricane warnings Miami to Stuart and north-east storm warnings north of Stuart to Titusville. Tropical storm of small diameter but accompanied by hurricane winds has changed its course during the night and now seems to be moving in a westward direction over Bahama Island which is about 100 miles east of West Palm Beach moving about 7 to 10 miles per hour. While storm conditions continue to change direction, all interests on the southeast Florida coast between Miami and Stuart should take extreme precautions against high tides and hurricane winds. Further bulletins today will be issued at about hourly intervals. Caution advised all vessels off Florida coast.

The Jacksonville office thereafter issued such frequent advisory and other warning messages as were necessary, up to and including the 5th of the month, following which, during the presence of the storm in the Gulf, several daily advisories were issued from the office at New Orleans.

The new hurricane warning service gave widest possible distribution of all storm information throughout the Miami and other districts by radio, telephone, telegraph, press agencies, and posted bulletins. In addition, all other interested agencies gave the fullest possible cooperation throughout the life of the storm.

ON THE METEOROLOGICAL HISTORY OF THE HURRICANE OF NOVEMBER 1935

By H. R. BYERS

(Weather Bureau, Washington, December 1935)

The tropical hurricane during the first week of November 1935, described by Mr. Hurd in this issue of the REVIEW, had several outstanding abnormalities. Principal among these were the high latitude and late season of its origin, the singular distribution of the meteorological elements around it, its unusual path, and its odd dissipation in the Gulf of Mexico. An explanation of these phenomena, if at all possible, would be highly desirable; the observational data, particularly from the upper air, are insufficient for the type of detailed study necessary for a complete explanation, but a few features of the storm are here discussed which may partially account for the observed facts.

Formation.—The hurricane center developed on October 30 about 300 miles east of Bermuda. At that time, and indeed for 2 or 3 days previously, there was a trough of low pressure extending northeastward from the Lesser Antilles toward Iceland and toward a large, nearly stationary low-pressure center between Iceland and the Faroe Islands. From a first glance at the synoptic charts it would appear that the center developed from this trough, but closer observation and physical reasoning indicate that it did not do so. Observations show that the storm was to the west of the trough when first noted, and that at that time the entity of the trough was still preserved. It hardly is conceivable that the trough could have formed into the hurricane center without the resultant circulation destroying the trough character.

The air transport over the North Atlantic had been dominated during the preceding days by an abnormally large and stationary Icelandic cyclone. This brought behind it a strong outflow of polar air which settled in a large belt of high pressure to the north of Bermuda. This pressure distribution was accompanied to the south of the high-pressure center by easterly winds which, being originally of polar origin, had had a long fetch over the warm waters of this section of the Atlantic before they reached the vicinity of Bermuda. The wind and pressure structure, in fact, looked very much like the picture of the northeast trade winds, only displaced far to the north. This air must also have been unstable vertically, at least with respect to saturated air, since it was polar

air being strongly heated from below incident to its passage over the warm water.

One of the most generally accepted views as to the origin of tropical cyclones is that they result from large-scale convection with its resultant converging winds which, under the effects of the deflecting influence due to the rotation of the earth, quickly develop a cyclonic circulation. It appears that the unusual conditions of the atmosphere, at the time and place of origin of this storm, were favorable for its genesis according to the above-mentioned hypothesis. That is, the presence of moist, unstable air caused convection over a wide area, with converging winds under the strong deflecting influence at that latitude.

The extra-tropical characteristics.—At the latitudes where this storm was located during its earlier history, the interaction of polar and tropical air currents dominates the circulation, particularly in the fall, winter, and spring. These air masses are integral parts of extra-tropical cyclones. At the latitude and season of development of this storm, it would almost inevitably involve in its circulation these various air currents. This should give the asymmetrical distribution of meteorological elements, such as precipitation, that is associated with the peculiar distribution of the air masses in an extra-tropical cyclone. The observational data of November 1, as shown by the weather map and vertical cross sections through the atmosphere along the coast of the United States, clearly indicate that this extra-tropical influence on the storm was present.

The map in figure 1 shows approximately how the air masses were distributed over the Eastern States and about the storm center on that date. On this chart, as on the others in this paper, cold fronts are indicated by heavy solid lines, and warm fronts by heavy dotted lines. The air masses are designated according to the classification of Willett. The positions of the fronts over the ocean are very uncertain. However, as will be seen from examination of the upper air data, these fronts must have been present somewhere off the coast, and even if they are placed 200 miles from their true position the present discussion will not be affected.